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Aortic Arch Angiography Prior to Carotid Endarterectomy. Is its Continued Use Justified?

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Patients with significant stenosis at the carotid bifurcation are traditionally subjected to four vessel aortic arch angiography prior to consideration for carotid endarterectomy. The advent of the non-invasive vascular laboratory has necessitated a reappraisal of this approach.

Aims:

1. *Determine the yield from aortic arch angiography and its influence on surgical management.*
2. *Evaluate the accuracy of clinical examination and the non-invasive vascular laboratory in the detection of aortic arch branch lesions.*

Methods: *One hundred and twenty-nine consecutive patients undergoing evaluation for carotid endarterectomy were prospectively enrolled into the study. The protocol entailed:*

1. *Clinical recording of upper limb pulses, blood pressure and supraclavicular bruits.*
2. *Duplex scan examination to evaluate proximal inflow into the carotid arteries.*
3. *Four vessel aortic arch angiography to detect aortic branch lesions.*

Data from the non-invasive tests were compared to angiography. Patients with aortic arch branch lesions were further evaluated to determine the proportion requiring additional surgery.

Results: *Nineteen patients had angiographic evidence of aortic branch disease (14.7%); six involved the common carotid artery, three the innominate artery and 10 the subclavian artery. All of these lesions were detected by the combination of unequal blood pressure, pulse deficit, bruit or duplex scan. Seven patients underwent additional surgery (5.4%) which included carotid-subclavian bypass (five), aortoinnominate bypass (one) and innominate endarterectomy (one).*

Conclusion: *In patients with significant stenosis at the carotid bifurcation undergoing evaluation for carotid endarterectomy, aortic arch angiography is unnecessary except in a small percentage of patients with abnormal clinical and non-invasive findings.*

Introduction

Patients with significant carotid bifurcation stenosis are traditionally subjected to aortic arch and selective carotid angiography prior to consideration for carotid endarterectomy (CE). The demonstration of arterial anatomy, congenital anomalies and the extent of arterial disease allows planned surgical management. This traditional approach has been questioned with the emergence of the vascular laboratory and the quest for minimal, non-invasive, cost-effective evaluation. Several factors may render prior angiography unnecessary: the detection and quantification of carotid stenosis can be accurately assessed by duplex scan; the presence of tandem distal intracerebral arterial stenosis is probably not associated with any increased risk of perioperative stroke; and the incidence of coincidental intracranial pathology is low and rarely necessitates additional surgery.

The aim of this study was to determine the yield from aortic arch angiography and its influence on surgical management; and to evaluate the accuracy of clinical examination and duplex scan in the detection of significant aortic arch disease.

Patients and Methods

One hundred and twenty-nine consecutive patients undergoing evaluation for CE were prospectively enrolled into the study over a 2-year period. All patients had significant carotid stenosis (>75%) as defined by established duplex scan criteria and confirmed on angiography. The majority (120) were white patients with an average age of 60.2 years. Seventy-four were

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Table 1. Clinical presentation ($n=129$).

	No.	%*
Transient ischaemic attack	82	63.0
Minor stroke	22	17.0
Global cerebral ischaemia	15	12.0
Asymptomatic stenosis	10	8.0

* % to nearest whole number.

male. The clinical presentation of this cohort of patients is shown in Table 1; the majority (82) presented with a lateralising T.I.A.

Clinical examination

Pulse status and blood pressure (BP) were recorded in both upper limbs in the sitting posture. Abnormal pulses were defined as being either weak or absent. The BP was measured in the conventional manner with a standardised cuff appropriate for the arm circumference. A systolic blood pressure difference of more than 20 mmHg was regarded as significant. In addition, the presence of supraclavicular bruits were recorded. All the above clinical information was documented on the protocol sheet by the ward clinician.

Duplex scan

All patients underwent a duplex scan examination by a single vascular technologist using an ATL 600 mk 5 machine. The status of common carotid artery flow was recorded as being normal, dampened (reduced peak systolic velocity less than 30 cm/s) or absent.

Arch angiography

All patients underwent a standard four vessel contrast study using digital subtraction angiography (DSA). No attempt was made at selective carotid studies. All the radiographs were interpreted by a single clinician blinded to the duplex scan results and detailed assessment was made of the status of the aortic arch branches (innominate, common carotid and subclavian arteries). Significant pathology was defined as >50% stenosis, occlusion or aneurysm.

Data from the non-invasive tests were compared and correlated with the DSA findings. Patients with aortic arch branch pathology were further evaluated to determine the proportion requiring additional surgery.

Table 2. Distribution of aortic arch disease ($n=19$).

	>50% stenosis	Occlusion	Aneurysm	Total
Innominate	3	0	0	3
Common carotid	3	3	0	6
Subclavian	7	2	1	10
Total	13	5	1	19

Table 3. Comparative accuracy of tests for arch lesions ($n=19$).

Site of arterial lesion	Clinical examination	Duplex	Angiography
Innominate	3	1	3
Common carotid	3	6	6
Subclavian	10	1*	10
Total	16	8	19

* Aneurysm.

Table 4. Accuracy of clinical examination in detection of subclavian or innominate pathology ($n=123$).

		Angiogram	
		Significant pathology	Normal
Examination	Bruit*/BP Inequality**	13	6
	Normal	0	104

* Sensitivity 68%, specificity 100%.
** Sensitivity and specificity 100%.

Results

Nineteen of the 129 patients had DSA evidence of significant aortic arch branch pathology (14.7%). Table 2 shows the distribution of disease in the aortic arch branches. Significant stenosis was present in the innominate artery in three, subclavian artery in seven and common carotid artery in three. Occlusion was present in the common carotid artery in three patients and the subclavian artery in two. One additional patient had a left subclavian aneurysm. Table 3 outlines the comparison between the clinical and non-invasive tests and DSA in the detection of significant aortic arch branch pathology. All the lesions were detected by the combination of clinical examination and duplex scan.

One hundred and ten patients had a normal aortic arch angiogram (Table 4). Clinical examination was normal in 104 of these patients. Six had a false positive examination due to the presence of supraclavicular bruit, with none of these attributable to significant systolic pressure in inequality. Four bruits were associated with insignificant stenosis and two were due to transmission of precordial murmurs. The duplex

scan examination of the proximal carotid arteries was normal in all of these patients.

Seven patients underwent additional surgery (5.4%) based on the decision of the attending surgeon. This included an aortoinnominate bypass (one), innominate endarterectomy (one) and carotid-subclavian bypass (five). The remaining 12 patients were not offered additional surgery as they were asymptomatic or had pathology remote from the symptomatic stenosis.

Discussion

This study demonstrated a 14.7% incidence of significant aortic arch branch pathology in patients presenting for treatment of carotid bifurcation stenosis. The majority of these were contralateral or unrelated to the symptomatic carotid lesion. Only 5.4% of patients required additional concomitant surgery.

The combination of a thorough clinical examination and duplex scanning was completely accurate in the detection of significant aortic arch branch pathology. The combination of a pulse deficit, unequal BP and supraclavicular bruit identified all patients with innominate or subclavian artery pathology in this study. However, auscultation of a supraclavicular bruit (sensitivity 68%, specificity 100%) was not as accurate as the presence of significant systolic pressure in equality (sensitivity and specificity 100%). A normal clinical examination excluded significant innominate or subclavian stenosis with a 100% accuracy. Palpation of carotid pulses is notoriously difficult, which accounts for those with significant proximal common carotid stenosis who remained undetected solely on the basis of clinical examination. However, duplex scan clearly identified these lesions in the same patients. Both clinical examination and duplex scan detected a left subclavian aneurysm in one patient.

This study did not specifically address the detection and clinical significance of vertebral artery disease. However, detection of proximal vertebral artery stenosis rarely necessitates further surgery, and often carotid endarterectomy alone results in amelioration of vertebrobasilar ischaemia under such circumstances.

Angiography is invasive and incurs the costs of a short hospital stay, contrast, catheters and labour. Complications may be related to the use of the catheter such as intimal tear, thrombosis, embolism and false aneurysm; or contrast, which may result in allergic reactions or renal failure. Selective cerebral angiography is more prone to neurological complications: a review of five prospective studies yielded a mean major stroke rate after cerebral angiography of 2.4%.[1] This risk has been added to the surgical arm of recently published prospective randomised studies (ECST, NASCET and ACAS), thus conferring an advantage to the medical arm. Avoidance of the use of prior angiography would therefore be of considerable benefit in this regard.

Studies[2,3] published approximately two decades ago drew attention to the increased risk of perioperative stroke in patients with carotid siphon stenosis and/or tandem intracerebral arterial stenosis. Recent literature has shown similar postoperative stroke and mortality in cohorts of patients stratified according to presence or absence of such intracranial arterial disease. Furthermore, the incidence of haemodynamically significant tandem carotid stenosis is low, being 4.8% and 4.6% in the studies reported by Matos *et al.*[4] and Akers[5] *et al.*, respectively. The introduction of transcranial Doppler[6] and its validating studies now allows accurate evaluation of intracranial arterial stenosis, thus strengthening the case against carotid angiography.

Computerised axial tomographic (CAT) and magnetic resonance imaging (MRI) scans have made angiography redundant in the detection of intracranial space occupying lesions. The emergence of magnetic resonance angiography may further improve accuracy of intracerebral lesion detection.[7]

Transoesophageal ecchocardiography allows accurate visualisation of atherosclerotic debris in the aortic arch.[8] Origins of the aortic arch branches remain relatively invisible to non-invasive investigations, and although the duplex scan provides indirect evidence of significant stenotic disease, aortic arch angiography remains the "gold standard" for detecting these lesions.

In the light of this evidence, it is prudent to adopt a pragmatic approach to the preoperative assessment and selection of patients for CE. A technically adequate duplex scan that confirms significant disease consistent with the clinical presentation and absent clinical or non-invasive evidence of proximal aortic branch disease should permit carotid endarterectomy without further investigation. Angiography is reserved for patients with an inadequate duplex scan or those who have positive clinical evidence of proximal disease, particularly significant systolic pressure inequality on the side being considered for carotid endarterectomy.

The relegation of angiography to a secondary role has resulted in the emergence of pilot studies undertaking CE without angiography, and several reports[9,10] using historical controls have confirmed the safety of this approach in selected patients. Using this evolving approach over the past 2 years, the postoperative stroke mortality rate has not changed in our own practice.[11]

The safety and efficacy of this approach can only be confirmed by randomised, prospective, controlled studies. At the present time, no such studies have been reported.

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